INTERNATIONAL STANDARD

ISO 10360-4

First edition
2000-03-15

Geometrical Product Specifications (GPS) — Acceptance and reverification tests for coordinate measuring machines (CMM) —

Part 4: CMMs used in scanning measuring mode

Spécification géométrique des produits (GPS) — Essais de réception et de vérification périodique des machines à mesurer tridimensionnelles (MMT) —

Partie 4: MMT utilisées en mode de mesure par scanning

Reference number
ISO 10360-4:2000(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 10360 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 10360-4 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

ISO 10360 consists of the following parts, under the general title *Geometrical Product Specifications (GPS) — Acceptance and reverification tests for coordinate measuring machines (CMM)*:

— *Part 1: Vocabulary*

— *Part 2: CMMs used for measuring linear dimensions*

— *Part 3: CMMs with the axis of a rotary table as the fourth axis*

— *Part 4: CMMs used in scanning measuring mode*

— *Part 5: CMMs using multiple stylus probing systems*

— *Part 6: Estimation of errors in computing Gaussian associated features*

Annexes A, B and C of this part of ISO 10360 are for information only.

Introduction

This part of ISO 10360 is a geometrical product specification (GPS) standard and is to be regarded as a general GPS standard (see ISO/TR 14638). It influences link 5 of the chains of standards on size, distance, radius, angle, form, orientation, location, run-out and datums.

For more detailed information on the relationship of this part of ISO 10360 to other standards and the GPS matrix model, see annex C.

The acceptance test and reverification test of this part of ISO 10360 are applicable only to a CMM that is capable of being used in a scanning measuring mode and may be used to determine the form of a surface or the parameters of an associated feature.

The tests specified in this part of ISO 10360 are performed in addition to the size measuring test according to ISO 10360-2, which are conducted without the use of scanning, and are designed to assess the performance of a CMM used in a scanning measuring mode. It is normally not useful to isolate the scanning probing errors from other sources of machine error.

Geometrical Product Specifications (GPS) — Acceptance and reverification tests for coordinate measuring machines (CMM) —

Part 4:
CMMs used in scanning measuring mode

1 Scope

This part of ISO 10360 specifies the acceptance test which verifies that the performance of a CMM used in scanning measuring mode is as stated by the manufacturer. It also specifies the reverification test which enables the user to periodically reverify the performance of a CMM used in scanning measuring mode.

The acceptance test and reverification test described in this part of ISO 10360 are applicable only to CMMs capable of performing scannings using any type of contacting probing system(s).

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 10360. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 10360 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 10360-1:—[1)], *Geometrical Product Specifications (GPS) — Acceptance and reverification tests for coordinate measuring machines (CMM) — Part 1: Vocabulary.*

ISO 14253-1:1998, *Geometrical Product Specifications (GPS) — Inspection by measurement of workpieces and measuring equipment — Part 1: Decision rules for proving conformance or non-conformance with specifications.*

International Vocabulary of Basic and General Terms in Metrology (VIM). BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML, 2nd edition, 1993.

3 Terms and definitions

For the purposes of this part of ISO 10360, the terms and definitions given in ISO 10360-1, ISO 14253-1 and VIM apply.

1) To be published.

4 Requirements for metrological characteristics

4.1 Error of indication

The scanning probing error(s), Tij, shall not exceed the maximum permissible scanning probing error(s), MPE_{Tij}, as stated by:

— the manufacturer, in case of acceptance tests;

— the user, in case of reverification tests.

The scanning probing error(s), Tij, and the maximum permissible scanning probing error(s), MPE_{Tij}, are expressed in micrometres.

4.2 Time for scanning test

The time for scanning test, τ, shall not exceed the maximum permissible time for scanning test, MPT_{τ}, as stated by:

— the manufacturer, in case of acceptance tests;

— the user, in case of reverification tests.

The time for scanning test, τ, and the maximum permissible time for scanning test, MPT_{τ}, are expressed in seconds.

4.3 Environmental conditions

Limits to be respected for permissible environmental conditions such as temperature conditions, air humidity and vibration at site of installation that influence the measurements shall be specified by:

— the manufacturer, in case of acceptance tests;

— the user, in case of reverification tests.

In both cases, the user is free to choose the conditions within the specified limits.

4.4 Stylus system

A ball-ended stylus with a nominal tip diameter of 3 mm shall be used for performing the test for CMMs used in scanning measuring mode.

Other limits to be respected for the stylus system configuration, to which the stated values of MPE_{Tij} apply, shall be specified by:

— the manufacturer, in case of acceptance tests;

— the user, in case of reverification tests.

In both cases, the user is free to choose the way in which the components of the stylus system are configured within the specified limits.

The form deviation of the stylus tip will influence the measurement results and shall be considered when proving conformance or non-conformance with specification.

NOTE It is recommended that a stylus orientation is chosen which will ensure all axes of the probe and the CMM are exercised simultaneously when performing the scannings.

4.5 Operating conditions

The CMM shall be operated using the procedures given in the manufacturer's operating manual when conducting the tests given in clause 5. Specific areas in this manual to be adhered to are for example:

a) machine start up/warm up cycles;

b) stylus system configuration;

c) cleaning procedures for stylus tip and reference sphere;

d) probing system qualification.

NOTE The stylus tip and the reference sphere should be cleaned before the probing system qualification so as to leave no residual film which could affect the measuring or test result.

5 Acceptance test and reverification test

5.1 General

The tests described are applicable for:

a) scanning on a predefined path to collect a high density of points (HP);

b) scanning on a predefined path to collect a low density of points (LP);

c) scanning on a non-predefined path to collect a high density of points (HN);

d) scanning on a non-predefined path to collect a low density of points (LN).

NOTE 1 Scanning to collect a high density of points is particularly relevant when information on deviations from perfect form is required. Scanning to collect a low density of points may be relevant to allow the optimization of speed when information on associated feature characteristics is required. In any case the test is not able to define completely CMM performance when it is used for either form measurement or associated feature calculation.

NOTE 2 If the CMM is to be used for a specific form measurement task (e.g. roundness), it is recommended that a standardized test for that measurement task is carried out.

NOTE 3 Surface roughness, surface discontinuities and lubricity of workpiece and stylus influence scanning performance. In this test these influence parameters are controlled producing results that may not reflect those obtained in real workpieces (see annex B).

5.2 Principles

The principle of the assessment method is to establish whether the CMM is capable of measuring within the stated:

— maximum permissible scanning probing error(s), MPE_{Tij}, by determining the range of the values of the radial distance R on a test sphere;

— maximum permissible time for scanning test, MPT_{τ}, by monitoring the elapsed time for the test.

The centre and radius of a test sphere is determined by scanning the test sphere in four target scan planes.

The scanning probing error(s), Tij, is calculated as the range of radii between the measured centre and all of the assessed scan points i.e. the absolute difference between the maximum and minimum measurement results.

In the following:

— acceptance tests are executed according to the manufacturer's specifications and procedures;

— reverification tests are executed according to the user's specifications and the manufacturer's procedures.

5.3 Measuring equipment

5.3.1 **Test sphere made of steel,** with

— nominal diameter of 25 mm

— surface roughness, Ra, no greater than 0,05 µm,

— hardness no less than HV 800.

The diameter and the form of the test sphere must be calibrated since they influence the test result and are to be taken into account when proving conformance or non-conformance with specifications.

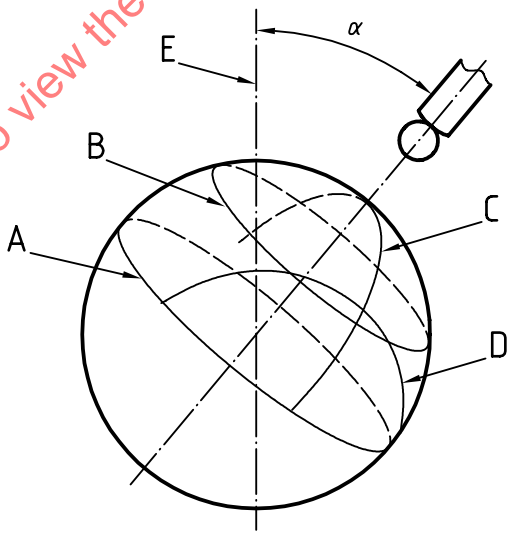
The test sphere shall be different than the reference sphere used for probing system qualification and shall be placed at the discretion of the user at a location other than the reference sphere.

5.4 Procedure

Clean the test sphere and fixture carefully, so as to leave no residual film which might affect the measuring or test result. The test sphere should be mounted rigidly to minimize errors due to bending.

The user is free to choose the orientation and location of the mounting of the test sphere, within the specified limits.

Take and record measurements of scan points on the test sphere for corrected scan lines on the surface of the test sphere in the four target scan planes defined (see Figure 1).



Key

A Target scan plane 1
B Target scan plane 2
C Target scan plane 3
D Target scan plane 4
E Axis of the ram

NOTE 1 Target scan plane 1 is on the equator.

NOTE 2 Target scan plane 1 and target scan plane 2 are parallel planes 8 mm apart.

NOTE 3 Target scan planes 2, 3 and 4 are mutually perpendicular.

NOTE 4 Target scan plane 3 goes through the pole.

NOTE 5 Target scan plane 4 is a plane 8 mm from the pole.

NOTE 6 α is the angle in which the stylus shaft is offset from the axis of the ram.

NOTE 7 The pole and equator of the test sphere are defined by the axis of the stylus shaft. It is recommended that a value of α of approximately 45° is chosen.

Figure 1 — Four target scan planes on a test sphere

The recommended distance between scan points is limited in accordance with Table 1.

Table 1 — Distance between scan points

Dimensions in millimetres

	Distance between consecutive scan points	Recommended maximum distance from target scan plane
for HP and HN	0,1	0,2
for LP and LN	1	0,2

Each of the four scan sequences must commence with the stylus at an intermediate point a minimum of 10 mm away from the test sphere. From this starting point the stylus should approach the sphere along a surface normal at a specified travel speed. Each of the four scan sequences must end with the stylus at an intermediate point a minimum of 10 mm away from the test sphere.

Record the time for scanning test, τ, from the intermediate point at the start of the first scan sequence to the intermediate point at the end of the fourth scan sequence.

NOTE The algorithms and parameters used should be those used for normal workpiece measurement on the machine. No additional filtering or other optimization should be used.

5.5 Obtention of test results

Compute the centre of the Gaussian (least squares) sphere (associated feature) using all the measured scan points of all four corrected scan lines.

For each of the measured scan points, calculate the radial distance, R.

Compute the scanning probing error, Tij, as the range of the calculated radial distances, R.

Compute the maximum absolute difference between any individual calculated radial distances, R, and half of the certified value of the diameter of the test sphere.

6 Compliance with specifications

6.1 Acceptance test

The performance of the CMM used in scanning measuring mode is verified if:

a) the scanning probing error(s), Tij, is (are) no greater than the maximum permissible scanning probing error(s), MPE_{Tij}, as specified by the manufacturer taking into account the uncertainty of measurement according to ISO 14253-1,

b) the maximum absolute difference between any individual calculated radius and half of the certified value of the diameter of the test sphere is no greater than MPE_{Tij} as specified by the manufacturer taking into account the uncertainty of measurement according to ISO 14253-1, and

c) the time taken for scanning test, τ, is no greater than the maximum permissible time for scanning test, MPT_{τ}, as specified by the manufacturer taking into account the uncertainty of measurement according to ISO 14253-1.

NOTE Since most spherical artifacts are certified for diameter, not radius, indent b) does not establish an additional determination of the error of indication of a CMM for size measurement, E (see ISO 10360-2). However, comparing the calculated radii to half of the certified value of the diameter provides a useful limitation on significant systematic errors in the measurement of size.

If the performance of the CMM used in scanning measuring mode is not verified by the test, the stylus tip and the test sphere should be thoroughly checked for dust or dirt influencing the measurement result. This being the case, they should be properly cleaned and the test should be repeated once, starting from probing system qualification.

6.2 Reverification test

The performance of the CMM used in scanning measuring mode is verified if:

a) the scan probing error(s), Tij, is no greater than the maximum permissible scanning probing error(s), MPE_{Tij}, as specified by the user. If compliance with specification shall be proved, the uncertainty of measurement shall be taken into account according to ISO 14253-1;

b) the maximum absolute difference between any individual calculated radius and half of the certified value of the diameter of the test sphere is no greater than, MPE_{Tij}, as specified by the user. If compliance with specification shall be proved, the uncertainty of measurement shall be taken into account according to ISO 14253-1;

c) the time taken for scanning test, τ, is no greater than the maximum permissible time for scanning test MPT_{τ} as specified by the user. If compliance with specification shall be proved, the uncertainty of measurement shall be taken into account according to ISO 14253-1.

NOTE The radius of a spherical artifact is often not certified under standard practice, so indent b) does not establish an additional determination of the error of indication of a CMM for size measurement, E (see ISO 10360-2). However, comparing the calculated radii to half of the certified value of the diameter provides a useful limitation on significant systematic errors in the measurement of size.

If the performance of the CMM used in scanning measuring mode is not verified by the test, the stylus tip and the test sphere should be thoroughly checked for dust or dirt influencing the measurement result. This being the case, they should be properly cleaned and the test should be repeated once, starting from probing system qualification.

7 Applications

7.1 Acceptance test

In a contractual situation between a supplier and a customer such as described in

— a purchasing contract,

— a maintenance contract,

— a repair contract,

— a renovation contract,

— an upgrading contract, etc.,

the acceptance test described in this part of ISO 10360 can be used as a test to verify the performance of a CMM used in scanning measuring mode in accordance with the specified maximum permissible scanning probing error(s), MPE_{Tij}, as agreed upon by the supplier and the customer.

If the supplier does not specify any limitation, the stated maximum permissible scanning probing error(s), MPE_{Tij}, applies for any orientation of the stylus and for any location and orientation of the test sphere on the CMM.

7.2 Reverification test

In an organization's internal quality assurance system, the reverification test described in this part of ISO 10360 can be used as a test to verify the performance of a CMM used in scanning measuring mode in accordance with the specified maximum permissible scanning probing error(s), MPE_{Tij}, as stated by the user with possible detailed limitation applied.

7.3 Interim check

In an organization's internal quality assurance system, a reduced reverification test may be used periodically to demonstrate the probability that the CMM conform with specified requirements regarding the maximum permissible scanning probing error(s), MPE_{Tij}.

The extent of the reverification test as described in this part of ISO 10360 may be reduced by the number of scan points being assessed.

Annex A
(informative)

Interim check

It is recommended that the CMM in a scanning measuring mode be checked regularly during the periods between periodic reverifications.

It is often useful to measure characteristic dimensions of material standards in addition to a test sphere. The measurements should be made directly after the reverification test: the position(s) and orientation(s) of the artifacts should be noted and subsequently repeated.

Annex B
(informative)

Workpiece related influences

The test described in clause 5 is not sensitive to all errors introduced due to the dynamic response of the system, e.g. those caused by internal or external discontinuities, surface roughness or lubricity on the surface being measured.

Additional tests may be carried out by the CMM user which determine the performance of the CMM used in scanning measuring mode for the measurement tasks to be carried out. A method applicable in most cases is to compare the results of a measurement in a scanning measuring mode with the results from a measurement in discrete point probing on the same workpiece. The differences of the results should be smaller than the limits defined in advance by mutual agreement between the manufacturer and the user.

The parameters used in scanning measuring mode (e.g. scanning speed, data density, filter settings) should correspond to those defined in advance. It is particularly important that this test include the scanning of discontinuities (e.g. an internal corner) if these occur in practice.

Annex C
(informative)

Relation to the GPS matrix model

For full details about the GPS matrix model, see ISO/TR 14638.

C.1 Information about this part of ISO 10360 and its use

This part of ISO 10360 specifies the verification methods for proving conformance of coordinate measuring machines with the specified MPEs. The tests specified in this part of ISO 10360 are:

— applicable only to a CMM that is capable of being used in a scanning measuring mode;

— designed to assess the performance of a CMM used in a scanning measuring mode;

— performed in addition to the size measuring tests according to ISO 10360-2, which are conducted without use of scanning.

C.2 Position in the GPS matrix model

This part of ISO 10360 is a general GPS standard, which influences the chain link 5 of the chains of standards on size, distance, radius, angle, form, orientation, location, run-out and datums in the general GPS matrix, as graphically illustrated in Figure C.1.

Fundamental GPS standards	Global GPS standards						
	General GPS standards						
	Chain link number	**1**	**2**	**3**	**4**	**5**	**6**
	Size						
	Distance						
	Radius						
	Angle						
	Form of line independent of datum						
	Form of line dependent on datum						
	Form of surface independent of datum						
	Form of surface dependent on datum						
	Orientation						
	Location						
	Circular run-out						
	Total run-out						
	Datums						
	Roughness profile						
	Waviness profile						
	Primary profile						
	Surface imperfections						
	Edges						

Figure C.1